Generative AI's potential in solving future mobility challenges: hype or hope?

Dr Robert Elliott Smith PhD FRSA
Director of AI & Data Science
Digital Catapult

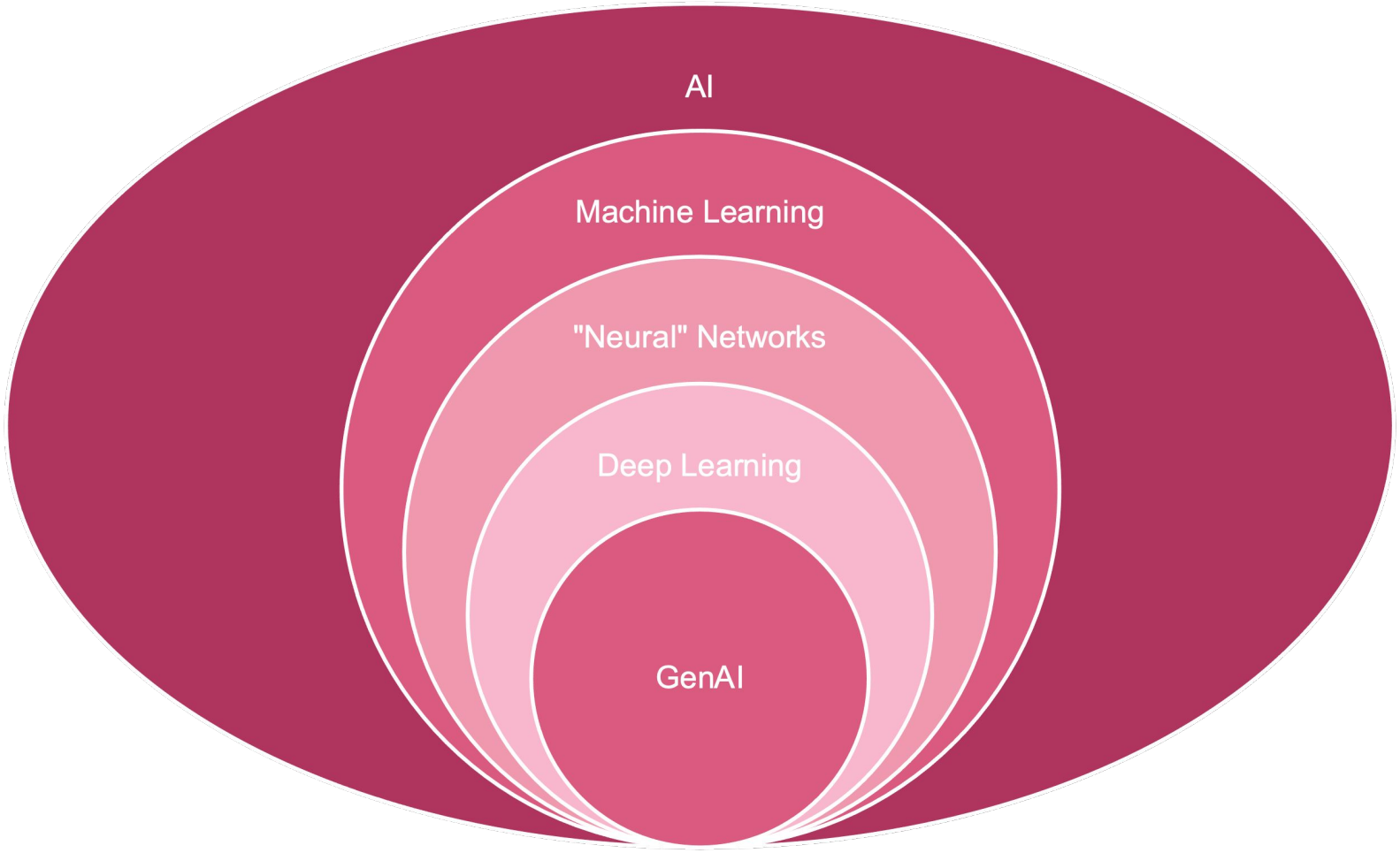
20240314



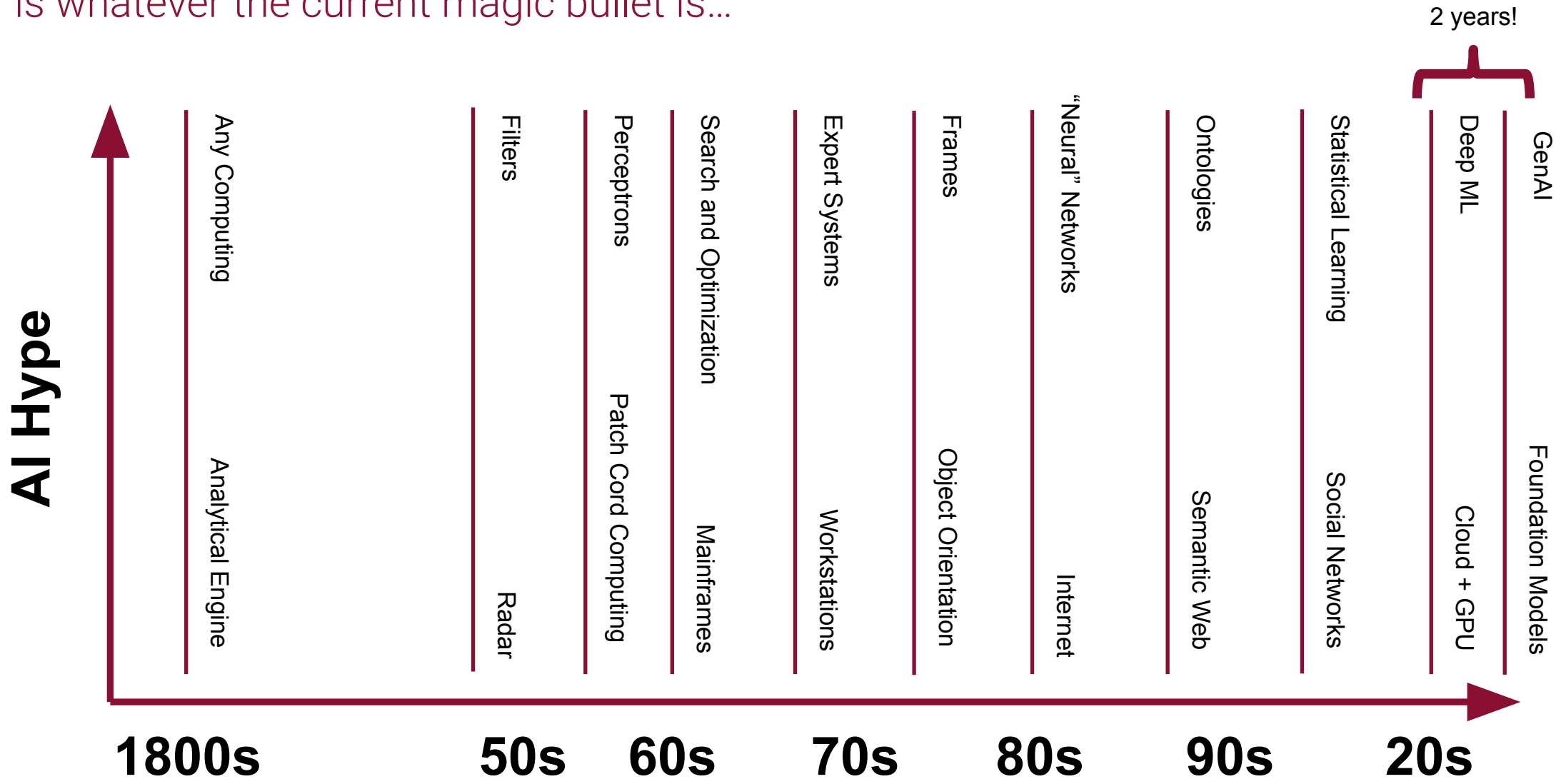
Robert Elliott Smith
Scientist, Technologist, Author, Advisor

What is we're talking about here, anyway?

- AI is not a technology, it is a goal
- GenAI, the latest thing in AI, is a part of a much bigger picture



AI is whatever the current magic bullet is…



GenAI is a genuine breakthrough

However

- It is not currently an “AGI” panacea
- It is purely a matter of faith to think that it will be
- It is being sold as a panacea, that can

  Reason

  Optimize

  Plan

  Predict

  And much more…

  (it is not at all clear that it can do these things well, if at all)
- Moreover, t hype is causing additional confusions in terms…

"AI" Generative *Design* Tools

- This motorcycle swingarm design was created by the AI-enabled tools in AutoDesk Fusion
- In 2018, *well before GenAI as we know it today, really "existed"*
- Under the hood, Fusion's generative design AI is not likely to be anything like what we call GenAI today
- It is most likely based on several kinds of ***heuristic optimization and simulation*** technologies
- Similar technologies are in all the major CAD systems:

ptc creo®

Ansys DISCOVERY

GENERATIVE SHAPE DESIGN CATIA V5

…and many more

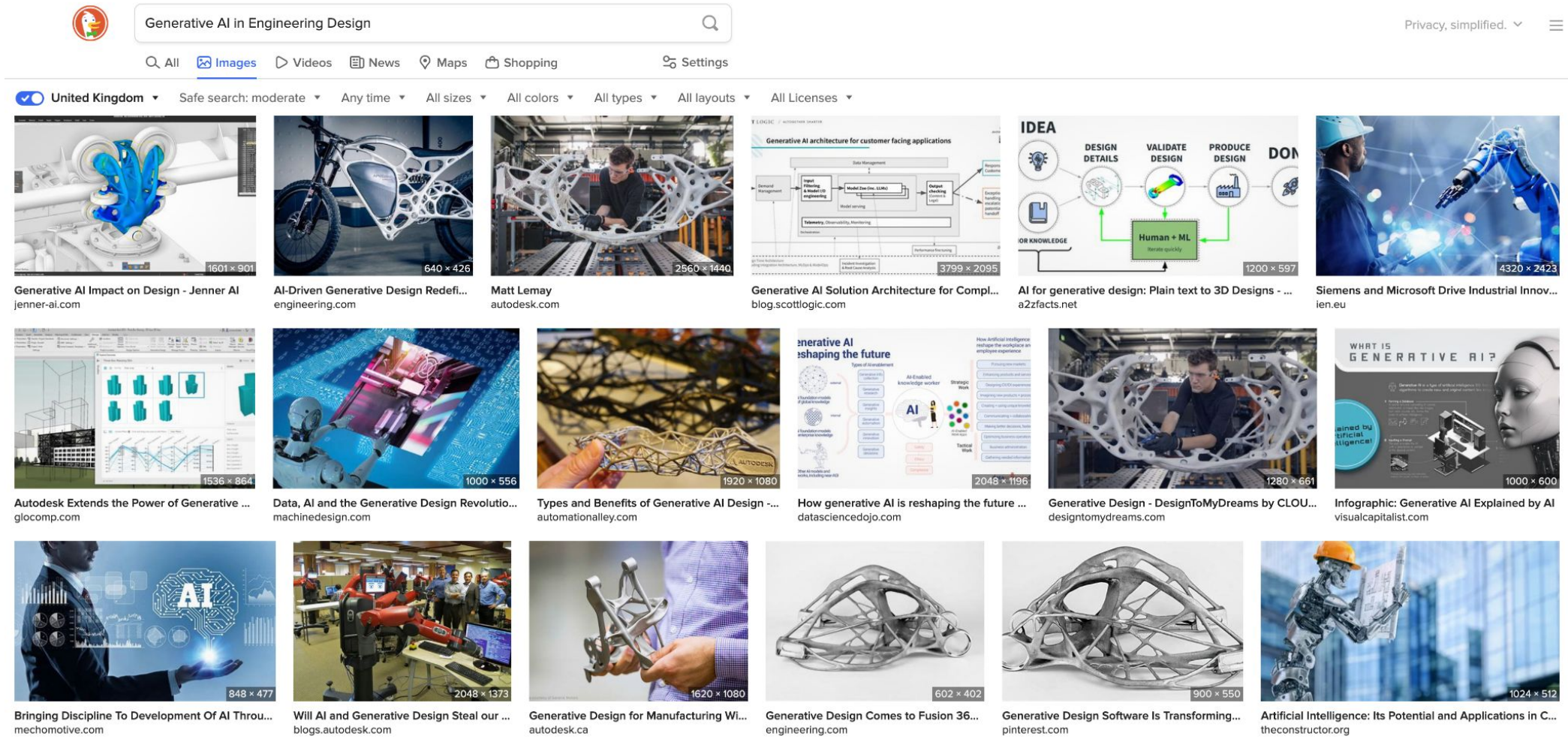
- The technology here is, **by definition, high TRL**
- GenAI, at least for engineering applications, is not…

AUTODESK Fusion 360



This generatively designed swingarm for Lightning's LS-218 electric bike was 3D-printed, then cast in A356 aluminum.

Generative Design and GenAI are being actively confused…



Generative Design and GenAI are being actively confused…



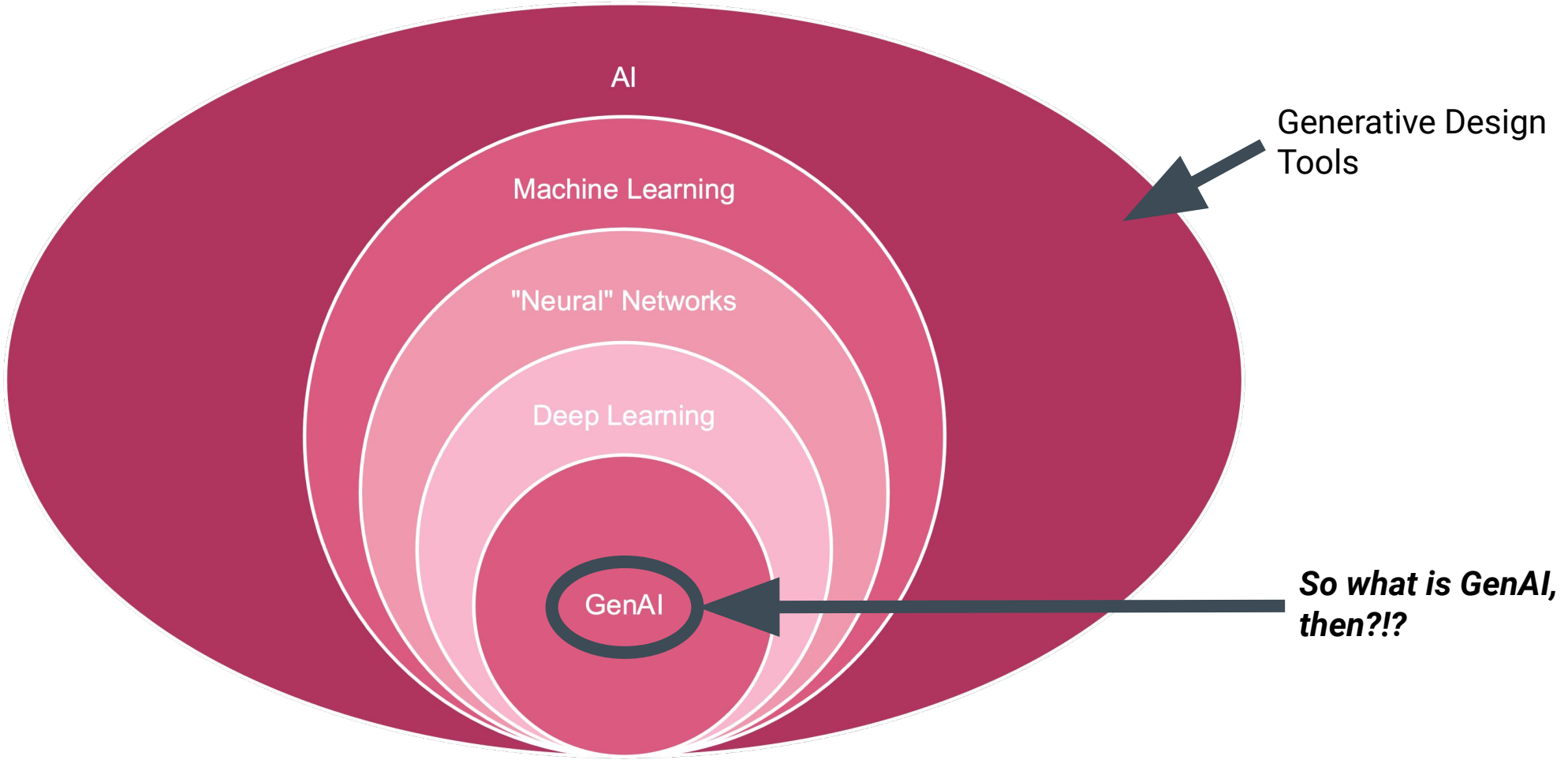
Figure 1. OpenAI's Dall-e generates multiple images based on the input requirements, in this case, a text prompt describing the desired image. The AI generates several options for the desired armchair including novel concepts such as using the avocado's seed as a pillow.

1.1 Generative Design

Generative Design is an iterative design process that generates multiple design outputs based on input constraints. OpenAI's Dall-e is an example of Generative Design for images (see Figure 1) [3]. Generative AIs have been applied to the fields of art, music, architecture, and structures. For structures, all leading CAD vendors are developing Generative Design products due to the power and relative maturity of the underlying algorithms. The examples in this paper were designed using Autodesk Fusion 360 Generative Design Extension

(for a clear point-of-view on the distinction, see the following from AutoDesk:
https://www.autodesk.com/design-make/articles/generative-design-and-generative-ai

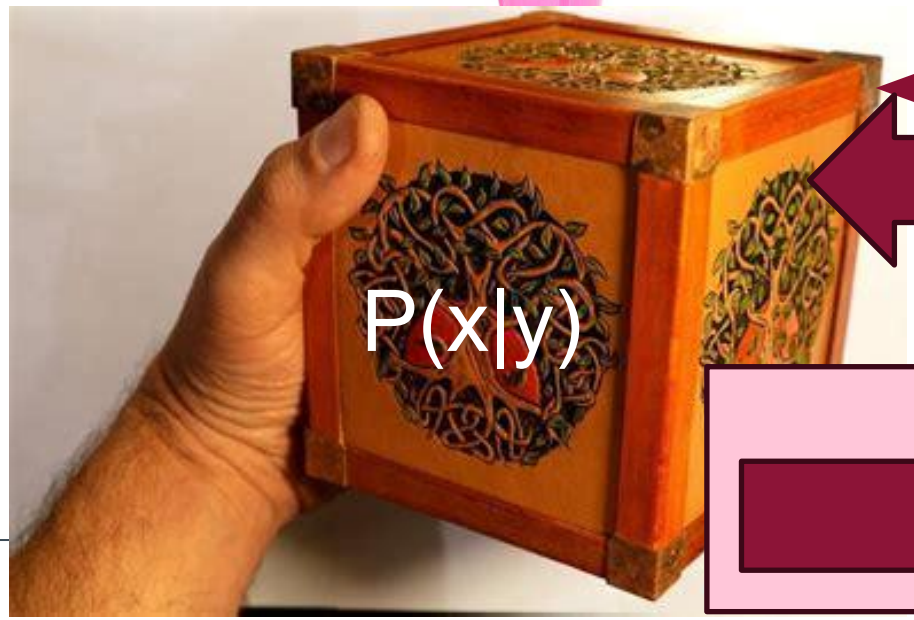
Different Tech, Different Promises and Problems…



500 billion words



175 billion parameters, tuning
96 refinement iterations (layers), so about
2 billion parameters per refinement.
Refinements tuned with days of the
world's most powerful computation.



y = context: prompts (including "one shot" documents, etc.), history of prompts, history of past outputs, etc.

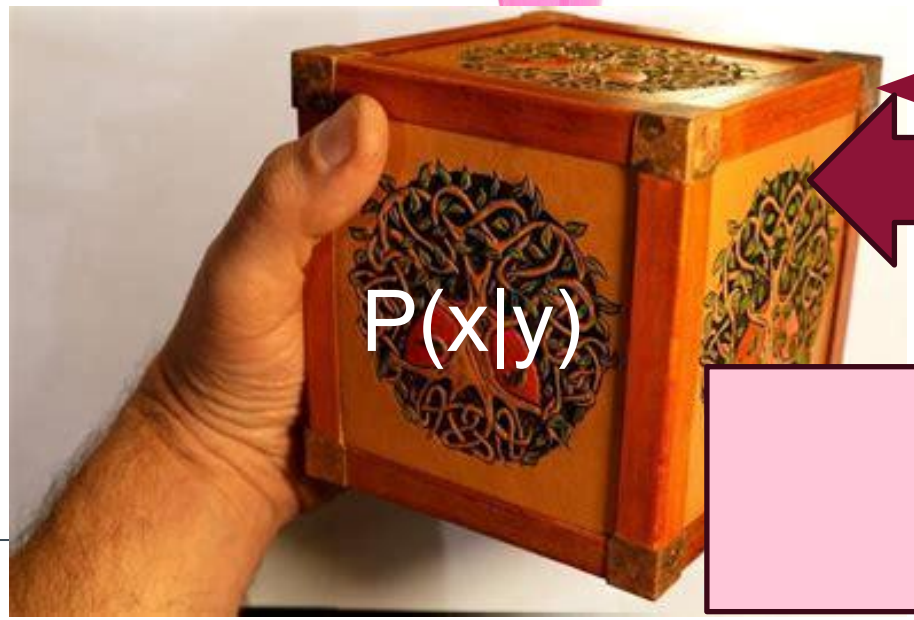
A Content Mashup Machine w/

Astounding Fluency

500 billion words



175 billion parameters, tuning
96 refinement iterations (layers), so about
2 billion parameters per refinement.
Refinements tuned with days of the
world's most powerful computation.



y = context: prompts (including "one shot" documents, etc.), history of prompts, history of past outputs, etc.

A Content Mashup Machine w/

Astounding Fluency

GenAI Does Amazing Things!



In tennis, two sides stand so poised,
On courts of green where skills are voiced.
With rackets tight and eyes so keen,
They chase the ball upon the scene.

The serve begins, oh what a sound,
It arcs and spins, over the net bound.
Across the court, it mustn't stray,
Or else a point is lost that day.

A rally starts, back and forth they send,
The ball in play, as foes contend.
A graceful dance, 'cross lines and court,
Each point fought for, a noble sport.

The rules are clear, a simple quest,
To hit the ball, do your very best.
Over the net, inside the lines,
With every shot, through tennis' pines.

The score ascends, from love to all,
But watch out for that dreaded fall.
At forty all, deuce is named,
Two more points won, the game's proclaimed.

In tennis, love means nothing here,
Only points matter, it's quite clear.
Tiebreakers when the score is tied,
A thrilling end, with skill and pride.

So, serve and volley, with all your might,
In tennis' game, both day and night.
A sport of grace, and strategy too,
With every match, champions ensue.

In courts of white or clay so red,
Tennis unfolds where legends spread.
With rules so fair, and spirit true,
In tennis, there's a place for you.

GenAI Does Amazing Things!



High-fidelity concept images of modern welding helmets powered by the Internet of Things that were created using a generative AI text-to-image software. Through iterative prompting, the industrial designer refined the initial designs to develop concept images with a futuristic aesthetic inspired by modern sports car styling. (Images are illustrative and were developed for this article.)

GenAI Has Substantial Problems!

- “Hallucinations” (incorrect and fabricated answers)
- Derivative and Inane Responses (facile answers that don’t add value)
- Toxicity (biased or damaging answers)
- Privacy, Copyright, and Security Risks (answers utlizing information they shouldn’t)
- As well as Cost Scaling and Sustainabilty Problems…
- But there are very particular problems relevant to engineering

Have a play with ChatGPT on a subject you *really* know well..



Rob:
Tell me more about this triangle circuit design

ChatGPT:
The "triangle" circuit design is a specific version of the classic Big Muff fuzz pedal circuit that was used in the earliest versions of the pedal. This circuit design is named after the ***triangle-shaped knobs*** used on some of these early pedals … The triangle circuit uses four transistors in a specific configuration that produces a smoother, more vintage-sounding fuzz tone than later versions of the Big Muff.

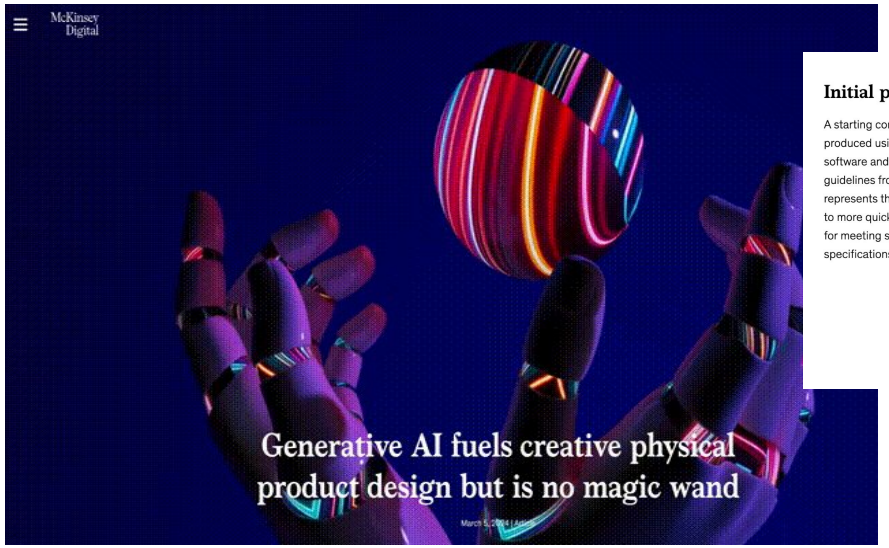
Have a play with ChatGPT on a subject you *really* know well..



Rob:
There were triangle shaped knobs?

ChatGPT:
Yes, the earliest versions of the Big Muff fuzz pedal, which used the triangle circuit design, featured **triangle-shaped knobs**. These knobs were used to control the pedal's volume, sustain, and tone parameters. The **triangular knobs** are one of the most distinctive visual features of the early Big Muff pedals and are highly sought after by collectors and enthusiasts.

These problems have definite implications in engineering applications



Initial prompt

A starting concept for a new bicycle pedal design produced using generative AI text-to-image software and developed based on initial guidelines from an industrial engineer. This represents the first phase of an iterative process to more quickly identify the best design approach for meeting specific performance and product specifications.



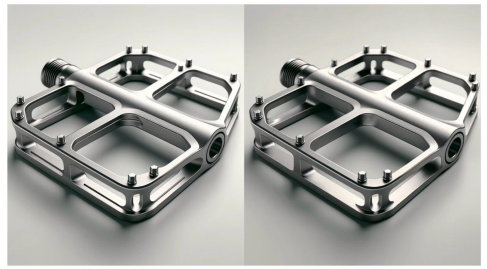
Prompt progression

Based on the software's initial output, an industrial designer then used iterative prompts to identify ways to reduce the amount of titanium in the pedal (thus making the pedal lighter) while improving component strength. Images illustrate the progression of concepts developed as the designer worked to finalize the raw output from the generative AI text-to-image software.



Final, refined, and manufacturable

The designer then refined the final raw output (on left) using image-editing software. To create the final concept (shown on right), the designer removed excess studs, adjusted the pedal braces to increase component strength, and made other adjustments to ensure manufacturability. (Images are illustrative and were developed specifically for this article.)





An unflyable and not manufacturable passenger drone produced by an AI-powered image generator. Note the uneven number of propeller blades, insufficient landing gear skids, and lack of doors for passenger safety. (Image is illustrative and was developed specifically for this article.)

These problems have definite implications in engineering applications

MIT News
ON CAMPUS AND AROUND THE WORLD
SUBSCRIBE

To excel at engineering design, generative AI must learn to innovate, study finds

AI models that prioritize similarity falter when asked to design something completely new.

Jennifer Chu | MIT News
October 19, 2023





GenAI must be developed to incorporate engineering-relevant metrics, like:

- Novelty & diversity
- Constraint satisfaction
- Performance & Quality

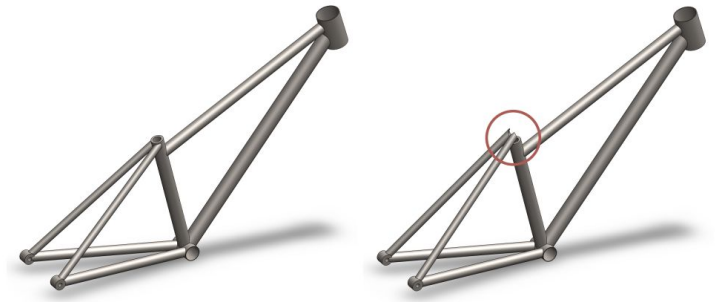
For focused domains, the means of incorporating these into engineering systems

This remains an area of research

Beyond Statistical Similarity: Rethinking Metrics for Deep Generative Models in Engineering Design

Lyle Regenwetter[1], Akash Srivastava[2], Dan Gutfreund[2], Faez Ahmed[1]
Massachusetts Institute of Technology[1], MIT-IBM Watson AI Lab[2]
regenwet@mit.edu, Akash.Srivastava@ibm.com,
dgutfre@us.ibm.com, faez@mit.edu

October 17, 2023



(a) Deflection: 0.05 cm (b) Deflection: 10.46 cm

Figure 1: Two very similar bike frames adapted from [12] with drastically different structural performance. By most distance metrics, these bike frames would be the most similar designs among a dataset of thousands. Yet, due to the disconnected geometry highlighted, they experience deflections that differ by over two orders of magnitude when subjected to the in-plane loading scenario.

Make not mistake, ***Gen***AI has powerful use cases in your industry today

- Scenario Generation
  - **in AV perception & decision making**
  - **predictive modelling in many application areas (traffic, manufacturing, etc.),**
- Natural language interfaces (with some caution)
- Idea Generation: in
  - **R&D**
  - **Product Development**
  - **Design, and more**
- Back Office functions
  - **generation and summary of documentation**
  - **“mining” unstructured data**
  - **Marketing**
  - **customer service, etc.**

But some things are still avenues that require fundamental AI development

- Incorporating new metrics and behaviours beyond statistical similarity
  - **Using domain-specific *knowledge models* that can respect constraints while generating for quality, performance, and innovation**

- Creating domain-specific datasets and training GenAI to go beyond text/images/videos-to-text/image/videos, to text/image/video-to-engineering specifications and solutions

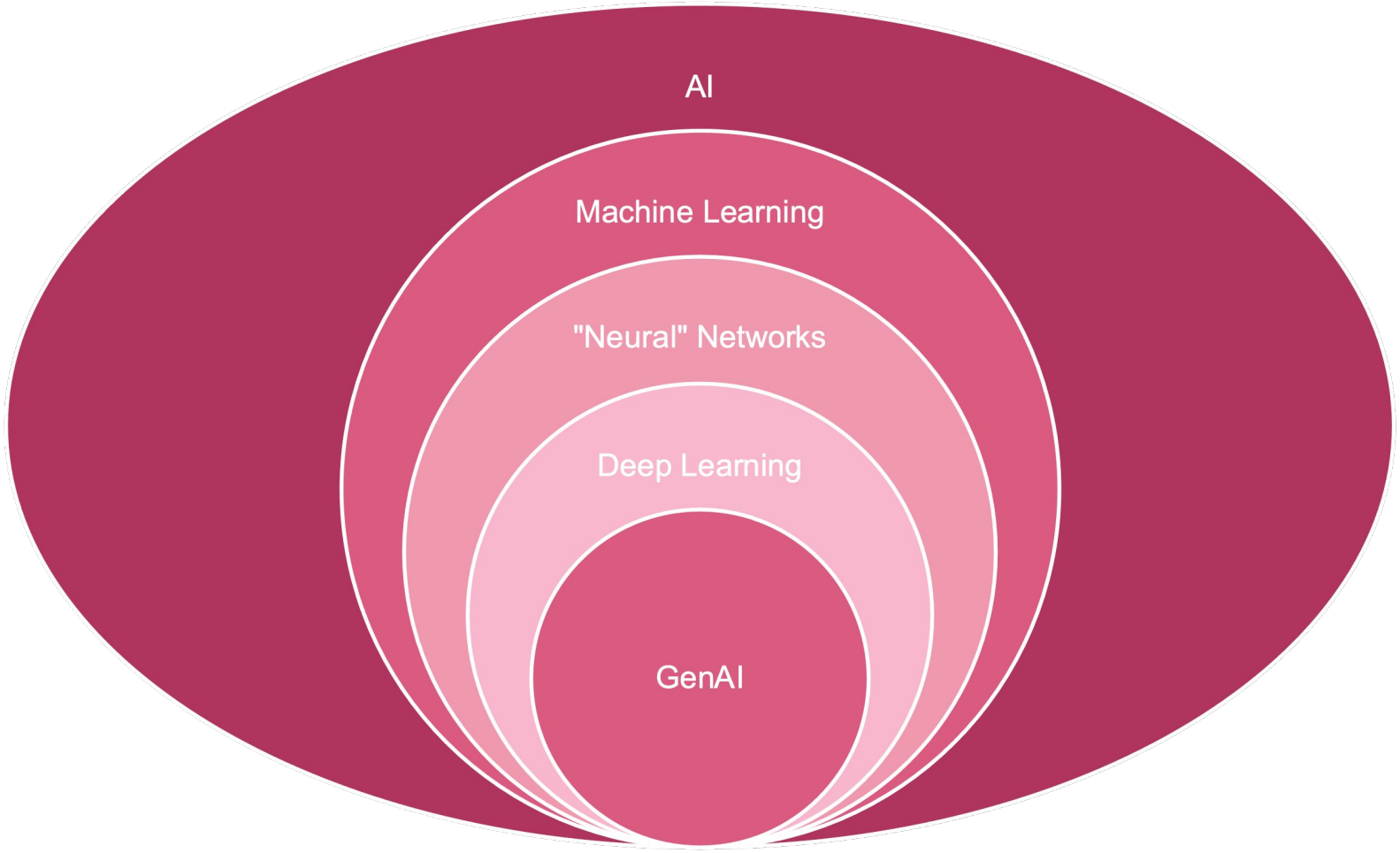
- Moving beyond AGI panacea goals to exploiting GenAI's real breakthroughs for focused value generation

- Fortunately, there are good signs this transition is already underway



P.S.

- AI is not a technology, it is a goal
- GenAI, the latest thing in AI, is a part of a much bigger picture





Robert Elliott Smith
Scientist, Technologist, Author, Advisor

CATAPULT Digital

Thanks!

robert.smith@digicatapult.org.uk
https://www.linkedin.com/in/rdrresmith/